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The Big Empty

By Richard Brook, Shelley Smith, and Mary Tisdale

> ***From the peak I looked over a broad landscape surpassing anything I had seen in emptiness and gloominess. Crusts of a dirty whitish clay rose through the sand, which is covered for long distances with white salt crusts. As far as the eye could see, no trace of vegetation, no plant, not a blade of grass, not even the almost always present artemisia, no trace of any animal, no impression from the foot of a living creature in this bare flat ground.***
>
> ***—Jacob H. Schiel describing the salt flats bordering the Great Salt Lake in 1853***

Home to the officially designated "loneliest road in America," the Great Basin has long been thought of as vast and vacant. Indeed, its various names evoke a feeling of expanse—the Great American Desert, Basin and Range country, the sagebrush ocean. Mountain men, explorers, and military expeditions crossed the Basin throughout the first half of the nineteenth century, most looking for something else, like a river passage to the sea. Wave after wave of emigrants moving to California and Oregon saw the Basin as a place to get through as quickly as possible.

With patience and a willingness to let the bigness of this country enter one's soul, an observer will see that the "Big Empty" is anything but empty. On the contrary, it is a great ecosystem, rich in plants, animals, and minerals. With the information and activities in this article and on the accompanying foldout, you can guide students to explore the Great Basin and begin to understand the ways in which such an arid and seemingly harsh environment can support so many living things, from antelope, bighorn sheep, jackrabbits, and raptors, to sagebrush, pinyon, mountain mahogany, and conifer forests. You also will be able to help students understand the transformations our land is undergoing and the important role they will play to ensure its long-term health and productivity.

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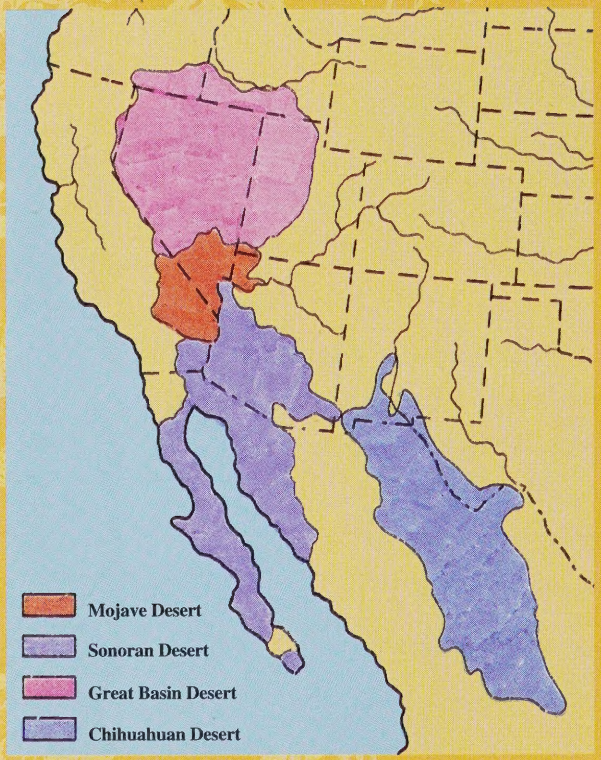
Photograph by Kelly Rigby



Shelly Fischman

Situated between Utah's Wasatch Mountains on the east and the Sierra Nevada on the west, the Great Basin is just what its name suggests—an area of interior drainage. It embraces most of Nevada, western Utah, snippets of southeastern California, southern Idaho, and southeastern Oregon. Geologic fault blocking that began 30–40 million years ago shaped the mountain-valley-mountain-valley corrugations in the Basin into 160 mountain ranges. In an unrelenting rhythm, peaks rise to over 3.3 km, then descend to flat valleys at around 1.2 km. The stretching and tilting continues today. Over the last 25 million years, the distance between the Sierra Nevada and the Wasatch Mountains has increased 80 km.

The Effects of Environmental Change

Water was once plentiful in the Great Basin, but today the area is a desert. The Basin receives an average of less than 25 cm of rain per year, about a quarter of the rainfall that occurs in forested areas of the eastern United States. A worldwide warming that began 8,000 years ago decreased precipitation and forced plants, animals, and prehistoric peoples to adapt to a warmer, drier environment. Some species were unsuccessful and became extinct. Others changed altitude, usually moving upslope, where they often became isolated on one or more mountain ranges.

These adaptations continue in the region's plant life today. Some of these plants earlier evolved by reducing the size and number of their leaves, thus minimizing water loss through transpiration; others shed leaves or entire branches during the dry season. Waxy coverings and surface hairs help some plants reduce water loss, and gray leaves lower transpiration by reflecting light. Plants like cacti eliminated their leaves altogether and now carry on the process of photosynthesis in fleshy stems. The cacti's succulent stems also store water to survive periods of limited moisture. Other desert plants have shallow, fibrous root systems to capture the moisture made available by cloudbursts, flash floods, and melted snow. Woody perennials may send roots as deep as 18 m to exploit ground moisture.

Unlike most species, certain desert plants open their leaf pores (called stomata) to obtain carbon dioxide only at night, when the lack of solar radiation and lower temperatures lessen the rate of transpiration. Other plants have higher salt tolerances, which enable them to exploit the saline waters that typify areas of the Great Basin.

Most Great Basin animals are solitary or live in small groups. They have fewer options for surviving the arid environment, although their mobility gives them an advantage over plants. Many animals sleep during the day or rest in the shade to minimize water loss. The light coloration of many animals reflects solar radiation, while hair and feathers create a dead air space that helps keep heat out and water in. Some animals have highly evolved metabolisms to make the most efficient use of available moisture, recovering all water in their kidneys before excretion of waste. Others estivate, the summer equivalent of hibernation.

The warmer, drier environment affected not only plant and animal species, but also the human population. Prehistoric people, who lived in small, dispersed groups for most of the Basin's 12,000-year human history, also learned to survive in the changed surroundings. These desert dwellers had a vast knowledge of the plants, animals, and other resources of their ecosystem. They learned which plants were edible, storable, useful for fiber and tool materials, or had medicinal properties. They knew the season of availability, and how plants were best processed and stored. They knew what alternatives were available if one source was unproductive.

Prehistoric peoples congregated in times and places of resource abundance and dispersed when resources were less available. From spring through fall, people traveled in small family bands, fishing and gathering green plants. Late in the summer, they would process and store seeds and dried meat and fish. During the late fall, several family bands would gather to harvest ripe pine seeds, also a storable staple. People gathered together in large groups during the winter, usually in mountain foothills or river valleys near firewood, water, and game, and subsisted primarily on stored foods. From A.D. 500–1100, people of the Fremont culture settled in farming villages in well-watered alluvial valleys. They developed a hybrid, called Fremont dent corn, which had greater drought and frost resistance.

Jerry Sintz

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Modern Day Challenges

Although the plants and animals of the Great Basin have developed highly unique adaptations to survive in a desert environment, the modern world often challenges their continued health and survival.

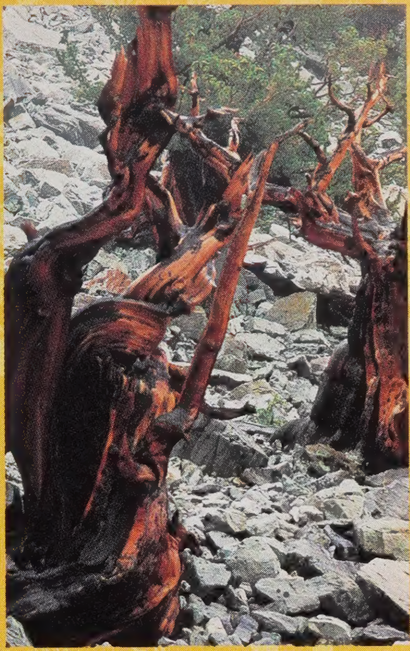
As the nineteenth century began, most of the human population in the Great Basin worked as miners, farmers, and ranchers; by 1900, mining, especially of gold and silver, drew many more people to the area. Today, these activities persist and, indeed, still support the Basin's rural economies. Of course, modern times have brought other sources of income to the area, particularly the military with its proving grounds, bases, and test ranges. Toxic waste incinerators and associated transportation facilities have moved into the heart of the spaciousness, along with gambling and other modern developments.

Human activities can have serious effects on the sensitive Great Basin ecosystem. Federal public lands constitute the vast majority of the area. The Bureau of Land Management (BLM), an agency of the Department of the Interior, is charged with managing most of these public lands. Land managers are grappling with how to accommodate both human needs and long-term sustainability of the ecosystem. Once degraded, arid ecosystems, such as the Great Basin, are generally unlikely to return to their original state and hence are termed "fragile," because they exhibit little resilience in the face of human-induced changes.

Scarce Water Resources: California's Mono Lake, located at the base of the Sierra Nevada mountains in the southwestern Great Basin, typifies what has happened to many Great Basin lakes in recent years. In 1941, the city of Los Angeles extended the Owens Valley aqueduct to the Mono Basin to provide water to its burgeoning population. Since then, the lake has been lowered by more than 12 meters. This has halved the storage capacity of the lake, doubled its salinity, and transformed shorelines into alkali flats. It also created a causeway from the mainland to a former island, allowing coyotes to reach and destroy the resident gull population. Fortunately, a recent agreement between the affected parties will begin the restoration of the lake.

In another part of the Great Basin, Las Vegas city water engineers are proposing to tap into the underground waters beneath remote valleys of eastern Nevada. Preliminary environmental studies suggest that the effects of this proposed engineering effort could be widespread. Groundwater pumping could lower the water table and destroy streams and marshes that support plant and animal life in desert basins. Even Death Valley National Monument, some 160 km away, could be affected.

Mining: For more than a decade, Nevada has been the nation's principal gold-producing state. Apart from its obvious uses for jewelry-making, gold's physical and chemical properties are without equal for use in such high-tech fields as medicine, space, architecture, and electronics. But the extraction of minerals does not come without a price. The mining of hard rock minerals—a group that includes gold, silver, and copper—is governed on the public lands by the Mining Law of 1872. This law allows miners and mining companies to acquire public lands with "commercial quantities" of mineral ore at a cost of only $2.50 an acre, with no royalties paid to the government. Many believe that the law is an anachronism, a relic of a bygone era when the government owned vast open areas that nobody else wanted and sought to promote interest in these lands. Others feel that the law provides still-needed incentives to encourage mining exploration and development, with their inherent risks.



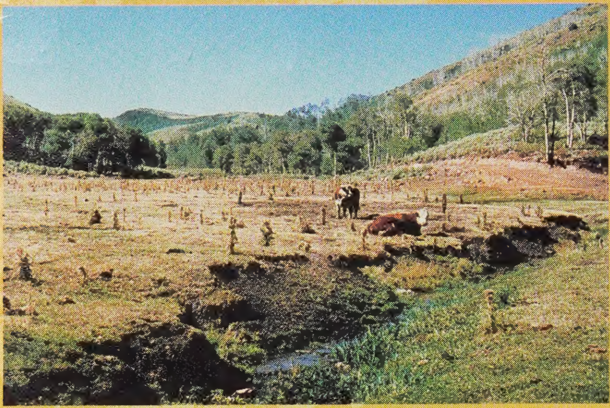
S. Poreda

Bristlecone pines (*Pinus longaeva* in the Great Basin) are the oldest living trees on Earth, with some surviving more than 4,000 years. They grow on rocky, windswept slopes between 2.2 km and 3.2 km in elevation, in shallow soils and with meager water. Bristlecones survive these conditions because they have only a narrow strip of living bark and add as little as one centimeter to their radius in a century. These mechanisms bypass what would otherwise be huge amounts of living tissue to sustain. Also, because their needles stay on for 20 to 30 years (rather than two to five years, as is typical of other pine species), bristlecones are able to photosynthesize and survive years of drought, when fewer needles are produced.

The Mono Lake Committee

Water consumption by Los Angeles County has halved the storage capacity of Mono Lake and further exposed rock columns previously underwater.

The effects of historic mining on the public lands are dramatic. Open shafts from abandoned mines pose health and safety



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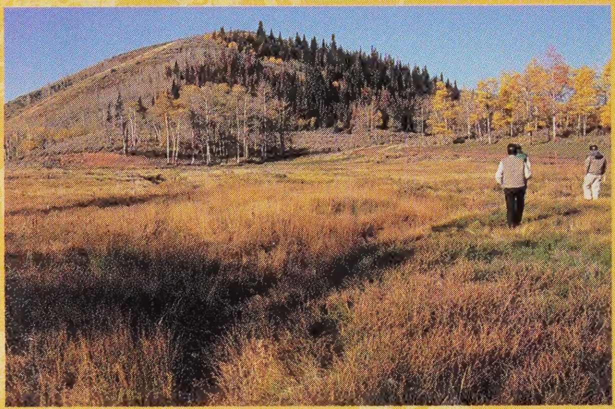
Vegetation increased significantly in the riparian area pictured above after fencing exclosures were constructed (see "after" photograph, below). Fencing helps control how long and when livestock graze riparian habitats. With such controls in place, livestock grazing can occur without severe overuse or trampling of riparian vegetation.



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hazards, threatening hikers with dangerous falls and exposure to radioactive materials. Unreclaimed mines also are the source of acid runoff and heavy metal contamination of streams. The pond-like reservoirs of cyanide solution used in modern heap leach gold mining have posed a threat to migratory waterfowl poisoned after mistaking the ponds for natural lakes.

Tourism: The expanses of the Great Basin provide one of the last refuges for people seeking solitude or an escape from urban congestion. While tourism generally is considered a "clean" industry that can be compatible with environmental protection, it usually carries considerable baggage. Hotel and infrastructure development (sewer, water, utilities), air and water pollution, erosion and sedimentation of heavily visited areas, trampling and degradation of vegetation and wildlife habitat, uncontrolled off-road vehicle use, and illegal artifact collecting and vandalism at archaeological and historic sites are activities that can result in negative effects on the ecosystem.

Grazing: Many small towns in the Great Basin are carrying on a traditional ranching culture that dates back to the 1850s, and many ranchers depend on public lands for the grazing of their cattle and sheep. Overgrazing at the end of the last century and the early part of this century, combined with frequent large floods, led to degraded riparian (streamside) areas. When cattle congregate along riparian areas, they urinate and defecate into the streams, and they trample streamsides and cause the banks to erode. As a result, stream channels widen, and sediment in the water increases; ultimately, streams become shallower. The loss of riparian vegetation exposes the waters to the sun's rays, raising water temperatures. Certain fish species cannot tolerate the higher temperatures. Increased sediment also threatens fish by reducing the amount of available oxygen in the water. In upland areas away from streams, congregating cattle can compact the soil, which reduces water infiltration, leading to erosion, gullying, and channel cutting. Today, government land managers and individual ranchers are working to restore and improve riparian areas. Although much work remains to be done, considerable progress has been made to improve conditions.

Tom Roberts

The squarrose knapweed, a noxious weed from Eurasia, expands its range by releasing a chemical inhibitor into the soil so that more desirable plants are prevented from growing in the same area.

Noxious Weeds: In the Basin, one of the major issues is noxious weeds. Most of these weeds began their invasion of the western rangelands in the nineteenth century. They came from Eurasia, where they had evolved along with their natural complement of insect predators, plant pathogens, fungi, and competition from other plants. Removed from their natural environment, these species have thrived and outcompeted native plants. On BLM lands alone (108 million hectares), weed infestation is estimated conservatively at 3.2 million hectares, with authorities predicting 8 million infested hectares by the year 2000. Weeds are spread by motor vehicles, hikers, horses, livestock, wind, water, and a wide variety of wildlife. One study, for example, has documented that 13 percent of spotted knapweed seeds pass undamaged through the digestive tract of mule deer, allowing them to sprout wherever droppings are left.

Land managers and private landowners are concerned about the spread of noxious weeds for many reasons. Noxious weeds are reducing the diversity and quantity of native plants, rendering habitats nearly unusable by wildlife, reducing forage, decreasing water quality, accelerating erosion, and increasing the economic costs of maintaining recreation and wilderness areas. The squarrose knapweed (*Centaurea virgata*), for example, expands its range by releasing a chemical inhibitor into the soil so that more desirable plants are prevented from growing in the same area. Another exotic, saltcedar (*Tamarix ramosissima*),

James Kirk Gardner

increases evapo-transpiration to the point that invaded springs cease to flow: the lower water table around these springs effectively precludes native species from surviving. Ranchers and those associated with the hunting industry suffer an economic impact because less forage is available to livestock and wildlife.

Native grasses of the Great Basin are easily destroyed by overgrazing. Overgrazing, in turn, helps speed the growth of noxious weeds such as cheatgrass. Like most other exotics, cheatgrass (*Bromus tectorum*) was introduced into the United States from the Asiatic steppe. Because it evolved under pressure from camels, horses, and other grazers, it can comfortably coexist with cattle. In fact, overgrazing gives cheatgrass a decisive advantage over the native plant species. This plant also grows throughout the winter, which allows it to send roots into deep pockets of moisture before its competitors can. Even on well-managed grazing land, cheatgrass is a tenacious competitor. It also can invade areas where no grazing has occurred. Eventually, cheatgrass becomes so dense that fire spreads faster; fire further weakens the native plant community, which evolved under a less frequent fire regime. Allowed to continue unabated, this cycle will result in a plant community of low diversity.

Wild Horses and Burros: In sharp contrast to exotic weeds, which people generally disdain, wild horses and burros tend to intrigue most people, although these animals also can pose a threat to the Great Basin ecosystem. More than 40,000 wild horses and burros roam the western ranges, descendants of domestic horses and burros that escaped or were turned loose from early Spanish settlements, ranches, mining communities, Native American tribes, and the U.S. Cavalry. Three wild horse herds even exhibit characteristics of the early Spanish Barb horse, brought to America in the 1600s. The Spanish Barb is related to the extinct tarpan horse, from which it derives such features as tiger-striped legs, mask-like facial markings, and an extra lumbar vertebra.

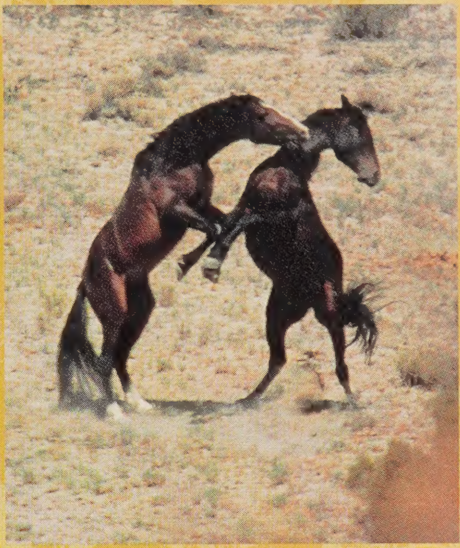
In 1971, Congress passed the Wild Free-Roaming Horse and Burro Act to protect these animals; this law, together with the absence of natural enemies, has led to steadily increasing herd sizes. To ensure the health and welfare of wild horses and burros, provide adequate forage for wildlife and domestic livestock, and maintain a thriving ecological balance, herd size must be controlled. Since 1973, BLM has administered the Adopt-a-Horse-or-Burro program, whereby excess animals are rounded up from the range and placed in private care.

An Ecosystem Approach

In the past, land managers focused on one issue at a time, whether it was wildlife, recreation, cultural resources, or cattle grazing. Today, managers acknowledge that such a singular focus rarely works, because ecosystems are complex interrelated systems. Consequently, land management agencies are shifting to an ecosystem-based approach to their task (see Smith, Brook, and Tisdale, 1994). The holistic philosophy involves resource users in implementing resource management practices and decisions, and in establishing goals for an area (for example, quality of life, forage production, or desired landscape). Because users are involved in setting these goals, and because the goals are constantly being monitored, evaluated, and updated to take into account critical issues, holistic resource management is gaining wider acceptance.

Prevention: Prevention of resource degradation is clearly the cheapest, most effective, and highest priority technique for addressing ecosystem challenges. Monitoring an ecosystem's components is the critical first step in determining where a system is at risk.

One such BLM effort, the "Riparian Wetland Initiative," involves inventorying the approximately 280,000 km of streams that the agency manages, including many in the Great Basin, to determine whether the streams are in "proper functioning condition." The BLM examines such characteris-

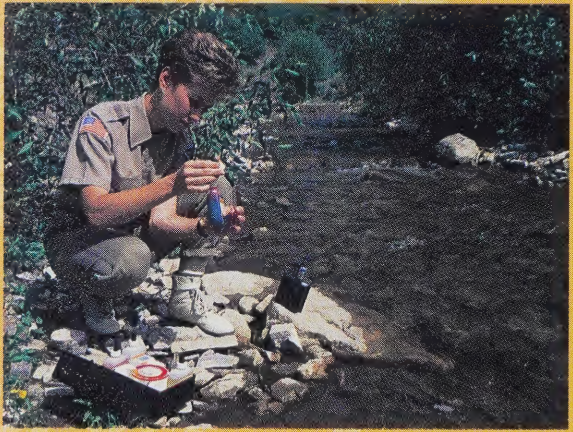


James Kirk Gardner

Nearly 40,000 wild horses and burros roam the western ranges, competing with cattle and wildlife for scarce forage. These animals, like cattle, can adversely affect riparian and range conditions. Land managers are seeking to mitigate these effects by controlling the number of animals that roam freely. Under the BLM Adopt-a-Horse-or-Burro program, excess animals are placed in private care off the open range.

James Kirk Gardner

Kangaroo rats are part of the Great Basin ecosystem. One species, the chisel-toothed kangaroo rat, has teeth that allow it to eat leaves from the shadscale bush, a salty plant that few other animals want. During the spring, kangaroo rats can eat the succulent leaves whole. During the rest of the year, the rats pass the "dry" leaves over their chisel-shaped incisors, extracting the inner tissue, which contains only 3 percent sodium, and discarding the rest of the leaf. Their specialized teeth allow the rat to reduce salt intake, control water balance problems, and sidestep competition with other rodents that survive primarily on seeds.



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Ongoing monitoring of water quality and other environmental conditions provides land managers feedback about the health of the ecosystem and the outcomes of land management practices.

Jody A. Gale

Since 1988, the BLM office in Fillmore, Utah, has been working with a host of groups on the Millard County Noxious Weed Control Day. Over 200 volunteers participate annually to dig up Scottish thistle.

tics as the width of the riparian zone, the presence of active beaver dams, the type and age of vegetation along the stream, the stability of the streambanks, and the stream sinuosity.

The BLM also is developing new methods to classify, inventory, and monitor rangelands under the "Rapid Assessment Program." Scientists select indicators of the biotic and physical environment to characterize an area in comparison to a reference area, where ecological processes are functioning properly.

The Environmental Protection Agency heads up another monitoring and assessment effort known as the "Environmental Monitoring and Assessment Program" (EMAP). This collaborative project attempts to place local monitoring results in perspective within a larger geographical context and to develop innovative methods for anticipating emerging problems before they reach crisis proportions.

Once areas are inventoried, prevention measures can be implemented to reverse trends toward degradation. In the case of weed management, history shows that if preventive measures are not initiated when the problem is first identified, the eventual control and restoration costs will be substantially higher down the road. One example from outside the Great Basin illustrates this point. In 1955, Okanogan County, Washington, could have spent $1,500 for knapweed control. Instead, in 1971, they spent $1.5 million in "cleanup" costs. According to one researcher, nine new weed species enter this country yearly, so early detection is very important.

To prevent or reduce the impacts of noxious weeds on natural ecological processes, land managers can change the period of use so that livestock graze when cheatgrass is most plentiful and before it reproduces; set prescribed burns to destroy stands of exotic weeds before their seeds ripen; apply chemical treatments and herbicides; reseed with "desireable" exotics or adapted native species that can outcompete invading weeds; or greenstrip, which involves planting strips of fire-resistant vegetation to reduce the size and frequency of wildfires. Insects also are being tested as a means of controlling noxious weed infestations. Also, uprooting goes a long way in controlling certain noxious weeds, such as the Scottish thistle.

Mitigation: Public lands in the Great Basin support extensive livestock grazing. Some adverse effects of this activity can be mitigated by wise range-management practices, such as rotating grazing use on three, four, or even five pastures over the course of several years. Under this system, grazing is rotated seasonally or annually, and ranchers base the rotation on the condition of available forage. A seasonal rotation gives plants time to complete their growth cycle and set seed for regrowth, while annual rotations allow pastures to be rested periodically. Rotational grazing also benefits wildlife that may be competing for the same forage as livestock.

To minimize damage to riparian areas caused by livestock, the BLM and the ranchers involved have begun to construct fences along certain streams. These "exclosures" have openings to allow livestock to reach the water, but the openings are placed in confined, unshaded areas with little forage to discourage livestock from congregating there. Fencing has allowed riparian plants to become reestablished; the riparian plants increase the storage capability of stream banks which, in turn, raises the water table and provides a buffer against drought.

Restoration: A BLM project undertaken in Elko County, Nevada, in cooperation with a host of partners, demonstrates some of the measures that can be employed to restore or rehabilitate an ecosystem after it has been degraded.

The BLM acquired about 18,800 rangeland hectares in exchange for 264 high-value hectares in Las Vegas. The city gained land crucial for future growth and development. In exchange, the BLM acquired key habitat for the threatened Lahontan cutthroat trout, consolidated some of its land holdings, restored the fishery

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The Great Basin Ecosystem

Artwork and associated research by Shelly Fischman

Appearances Can Be Deceiving

Kelly Rigby

along the Marys River, and met some of the recreational needs in Elko County. An activity on the accompanying foldout provides a detailed account of how the citizens of Elko County worked with the BLM to improve the health of the land in a manner that resulted in economic and other benefits.

A Great Basin Full of Activities

- To help students understand the effect of salt on plants, obtain three identically sized plant cuttings rooted in water. Place one plant in a 10 g/L salt solution, another in a 50 g/L salt solution, and a third in plain water. Have students record the effects on the plants' roots and leaves.
- Residents of Las Vegas use twice as much water per capita as those of Tucson, Arizona, also located in a desert environment. Have students investigate why this is so and the kinds of measures Las Vegas could take to conserve water. (They could landscape with native desert vegetation, which requires less water; install showerheads and toilet tanks that use less water; establish restrictions on what times of the day and year people can wash their automobiles; and have restaurants offer water only upon request.)
- Have students design a plant or animal that is adapted to living in an arid environment. Include at least four characteristics that help this species survive.
- Have students research the other three deserts that occur in North America (Sonora, Mojave, Chihuahua) and identify their different characteristics. Compare and contrast with the Great Basin desert.
- Obtain two small cacti and two leafy plants (but please don't dig up native or wild ones). Over the course of two months, have students water only one of the cacti and one of the leafy plants, and record their observations of all four plants. After two months, the children can dissect both the cacti and observe the level of water accumulated in the fleshy parts of the plants. (Students must wear heavy, protective gloves for this activity.)
- To point out the Great Basin's impact on the national economy, have students research some of the resources derived from the area, including gold, potash, magnesium, pumice, salt, silver, water, beef, mutton, brine shrimp, pine seeds (sold as "pine nuts"), recreation, and scientific data

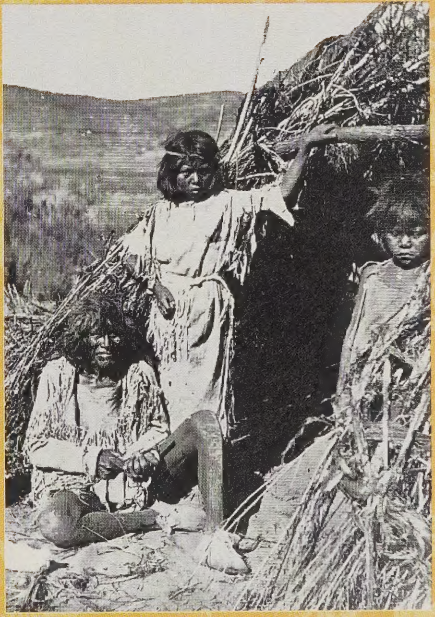
James Kirk Gardner

At the turn of the century, disease, fragmentation of habitat, and other factors led to a serious decline in bighorn sheep populations. Great Basin land managers have worked together to reverse this trend by capturing animals in areas with thriving populations and reintroducing them into the Basin.

Looking to the Future

The "Big Empty" is no longer a vacant expanse with room for every use. Growing human populations; demands for water, minerals, and range forage; tourism; the maintenance of rural economies; and diverse plant and animal communities all strive for their place in the Great Basin. Compounding the problem are the serious ecosystem problems we already have. Land managers and local communities will have to make tough choices to achieve healthy ecosystems. Active public participation and partnerships among communities, land managing agencies, and private landowners will be essential to find solutions that everyone can live with. Finding these solutions is not only a local matter, because decisions about public lands have significance to our nation as a whole.

As tomorrow's decision-makers, today's students will play a key role in determining how our public lands are used, in developing new environmental technologies, and in finding creative solutions to tough problems. Their contributions will affect environmental conditions not only in this country but also in other countries around the world, who look to America for help in combating environmental challenges. To fulfill this responsibility, students will need to be informed about all sides of an issue and to understand why healthy ecosystems benefit everyone.



Utah State Historical Society

Paiute Indians, *circa* 1873, in front of a *wickiup*, a temporary brush structure. Typically, early Great Basin peoples moved to where resources were seasonally available.

The Great Basin

Charting the "Sagebrush Ocean"

Ecosystem Concepts and the Great Basin

Scale

Ecosystems within the Great Basin occur at different scales, with smaller systems nested within larger ones. The Great Basin is variously defined by hydrographers, physiographers, historians, and biogeographers, although there is general agreement that the core includes the area from the Sierra Nevada on the west to the Wasatch Range on the east, and from south of the Snake River Plain on the north to the creosote bushes and black brushes that define the beginning of the Mojave Desert on the south. The Basin ecoregion includes the virtually lifeless sun-baked playas, alkaline flats that are home to salt-tolerant plants, salt lakes in which brine shrimp and flies reside, sand dunes teeming with various rodents, marshes that are crucial habitat for migratory waterfowl, vast expanses of sagebrush, the pinyon-juniper woodlands, the mountain islands isolating remnant plants, the aspen glens, and the subalpine forest that is home to the oldest living trees on Earth, 4,000-year-old bristlecone pines.

Jerry Sintz

Connections

The living and nonliving components of Great Basin ecosystems are connected in an interdependent web, and some of these connections are very complex and difficult to perceive. This is illustrated by the subsurface water supply, referred to as the carbonate system, one of the two aquifers supporting plant, animal, and human life in the Basin. To address Las Vegas's water needs, city water engineers are proposing to tap into the underground waters beneath remote valleys of eastern Nevada. The project would involve a system of 145 huge wells spread across nearly 20 percent of Nevada and connected by 1,600 km of pipeline. Preliminary environmental studies suggest that the effects of this proposed engineering effort could be widespread. Some critics maintain that groundwater pumping will lower the water table, destroying streams and marshes that support plant and animal life in desert basins and possibly affecting even Death Valley National Monument, some 160 km away.

Cycles and Change

Great Basin ecosystems are constantly cycling and changing over time and space. Some of these changes are the result of natural cycles, such as the water cycle, while others are the result of natural phenomena, such as climatic events or geological processes, or human-induced changes. Consider, for example, the environmental change recorded by the distribution of bristlecone pines. One specimen accidentally cut down by a researcher was more than 4,900 years old. Because bristlecone wood remains undecayed on the ground long after a tree has died, it has been possible to establish a tree-ring chronology for the species in excess of 9,000 years. Consistently, the dead specimens of bristlecone pine are found at a higher elevation than the living descendants, up to 150 m higher in one of the Great Basin's mountain ranges. Using tree-ring dates, we know that bristlecones were able to survive at a higher elevation during the Hypsithermal of 8,000 years ago, when summer temperatures were higher. Interestingly, over the last century Great Basin summer temperatures have once again been on the rise, and this has allowed seedlings of bristlecone pine to take root at higher elevations, just as they did during the Hypsithermal.

Diversity

Healthy ecosystems are characterized by biodiversity. In the Great Basin, scientists have found that particular plant species, such as shadscale and other saltbushes (*Atriplex* species), have evolved a remarkable strategy for diversification. The plant has an increased number of chromosomes, a trait known as polyploidy. This variation allows *Atriplex* species to adapt to different environments and soil conditions. Fourwinged saltbush (*Atriplex canescens*) has the widest distribution of any perennial member of the genus, allowing it to grow from central Mexico to southern Canada and from Nebraska to the Pacific. (Trimble, S. [1989]. *The sagebush ocean: A natural history of the Great Basin* [p.86]. Reno/Las Vegas: University of Nevada.)

Balance

In healthy ecosystems, the plants, animals, and other elements are able to regulate themselves and respond to stresses and changes. Fire plays a different role in the "natural" Great Basin ecosystem than it does in a disturbed environment. In areas that have not been disturbed, most native grasses grow in distinct clumps with only sparse vegetation in-between. In an undisturbed community, these spaces are covered by a thin layer of lichens, mosses, and other organisms, making up a cryptobiotic crust. Because the grasses grow in clumps, and because the cryptobiotic crust does not carry fire, fire does not spread easily in a native plant community. Also, because many of the native plants stay green longer than exotics, the onset of the fire season is delayed.

Kelly Rigby

Native or Not?

By Shelley Smith

Native plants are a critical element in healthy ecosystems; they have evolved locally, and so are adapted to their soil and moisture. Often, native plants are more resilient to pests, droughts, diseases, and nutrient shortages than are exotic plants. Some nonnative weeds can outcompete native species but, in general, are less resilient to stresses over the long term. Wildlife depends on native species for food and habitat—just plant an indigenous berry bush in your yard and watch the birds flock to it!

Introduced species can fit into native plant communities, but frequently they displace native plants, causing disruption in the ecosystem. The activity that follows has students explore local plant communities and research the history of plants they find. Students living in urban areas without access to parkland might focus their collection on tree leaves or vegetation growing in undeveloped lots.

Getting Prepared

Begin by checking the rules for collecting plant specimens from public lands or in parks, and ask for permission from owners of any private lands you'd like to explore. (As an alternative to actually collecting plants, you might bring along plant identification guides and photograph or sketch and measure specimens.) Next, contact a local agricultural or land managing agency, a university botany department, or a museum to learn if there are any rare or endangered plants that students should not collect. With the children, discuss avoiding any such plants, as well as any poisonous or irritating plants, such as poison ivy and stinging nettles (you might distribute photocopies of these plants for easier identification).

Explain to students the proper procedures for collecting plant specimens: take care not to trample vegetation, and take only the minimum necessary to make an identification (one sprig with leaves and flower for woody plants; for others you might need the whole plant, but uproot a plant only if there are at least 20 others nearby). Once the children clearly understand these rules, they are ready to collect.

To the Field and Back

Have each student collect up to six different plant specimens during their walk. Back in the classroom, the children should press the plants between layers of newspaper (either in a press or beneath a heavy book). When the plants are dry, they can be mounted onto card-stock with diluted white glue. Students should then refer to plant guides and other references to label each plant with its common and scientific names.

After everyone has dried, mounted, and labeled their specimens, the children should begin to conduct research on their plants, referring to accounts of local history as well as plant guides. If the species is native, students should try to discover the following:

- What is the plant's place in a food web?
- What animals use the plant for food or shelter?
- What do humans do with the plant? What might they do with it in the future?
- Is the plant species increasing or decreasing in number in your area?
- Are there threats to the plant's existence?
- What can people do to ensure that this plant thrives?

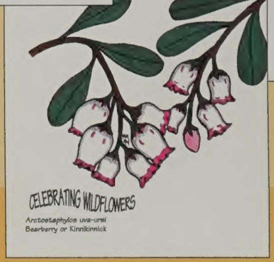
If the plant is nonnative, students should investigate the following questions:

- When, why, and how was the species introduced locally?
- What are the drawbacks of its presence?
- What are the benefits of its presence?
- What animals use the plant for food or shelter? Are these animals native or introduced species?
- What natural balancing mechanisms kept the plant in check in its place of origin?
- Does this plant threaten native plant communities? If so, how?
- What can people do to ensure that this plant does not damage native plant communities?

To conclude the activity, have students summarize their findings on a card attached to the mounted plant specimen and create a class display of their work.

Extensive Learning

To extend this lesson, consider visiting an arboretum or herbarium at your local college, museum, land-managing agency, or university. Botanists there can discuss native and nonnative plants with your class. Alternatively, you might invite to your class a botanist, wildlife biologist, member of a garden club or native plant society, local agricultural extension service agent, or coordinator of your state's department of weed and pest control. These people can also be sources of information to students as they do their research. Finally, telephone the "Wild Hot Line," at 800-354-4595 from April through July, to learn about events celebrating wildflowers on the nation's public lands.



Celebrating Wildflowers Illustrations by Karl Urban

Restoring the System

By Shelley Smith and Kelly Letts

After students have come to understand ecosystem concepts, consider with them a set of real-life ecosystem problems. The restoration of a damaged riparian ecosystem along the Marys River in Nevada provides an opportunity for students to apply problem-solving skills to an ecosystem issue. After completing this activity, students will comprehend how an ecosystem can be damaged and repaired, and how citizens can get involved in managing our public lands.

Begin by photocopying the three informational boxes below and making enough copies so that each student has a set. Divide the class into groups of three or four. Explain that students will analyze a case of ecosystem damage in the Great Basin. Let the children find Elko and Elko County on a map of Nevada; the Marys River may also be shown.

Distribute the card entitled "Beavers" to each child. Then ask each group to brainstorm a list of ways that removing the beaver community could change the ecosystem. Students should share their ideas with the class, while you record them on a master list. Through focused questioning, guide students to think of outcomes they may have overlooked. Go through the same process with the remaining two cards, "Cattle" and "Restoration."

Conclude the exercise by having each group prepare an ecosystem plan for the Marys River restoration. The plan should include who (possibly interest groups and BLM partners), what, when (timing matters; for example, beaver should not be reintroduced until there is vegetation there for them to use), where, and how. Students may want to send their plans to the BLM.

To involve your students in ongoing decisions, write to BLM, Wells Resource Area, P.O. Box 831, Elko, NV 89803, and ask to have your school placed on the mailing list for Environmental Analyses (EAs) of future land exchanges and other projects in the Marys River ecosystem. These analyses consider the consequences of each proposal and provide a 30-day period for public comment. Students can review the EAs and communicate their views in condensed form to the BLM.

As an extension, you might investigate riparian or water-quality issues in your state by contacting land managing agencies, national and state fish and wildlife services, local water-quality agencies, or the local agricultural service. Do students see any parallels between local issues and the Marys River situation?

Information about beavers

When beavers are removed from the ecosystem, several things can happen, depending on the vegetation present. In areas where woody plants grow, vegetation once harvested by beavers for food, dams, and shelter increases in size and density until sunlight no longer reaches the stream. When this happens, the stream loses its capacity to support various life-forms (for example, the insects that the fish eat). Thus, the stream becomes less and less productive.

In areas where woody vegetation does not grow, the removal of beavers means that their old dams are not maintained. Flood water will breach the dams, causing accelerated erosion and bank cutting. Water cascading through the old dams increases stream velocity, allowing it to scour once-stable channels and streambanks. The eroded sediments and soils are then carried away by the turbulent water. Raw, open streambanks can no longer support vegetation that reduces stream flow velocities, and the degradation cycle continues until positive events cause the aggregation cycle to start over.

Information about cattle

When cows gather in an area, vegetation is eaten or trampled and the cows defecate and urinate into streams. As cattle drink and trample vegetation, they cause the banks to erode and vegetation there to die. Once the plants along the banks disappear, there is less shade, so water temperature rises. Erosion increases, causing more sediment to be carried by the stream. Because the stream banks are not stabilized by vegetation, the current starts to cut a straighter stream course, resulting in the loss of stream pools. Overall, water quality decreases, and higher water temperatures, more sediment, and fewer pools threaten the stream's fish population. Other wildlife that live in the area have difficulty finding food and shelter, so those animals move to another area or die off, reducing the diversity of the local ecosystem. Such damage can be prevented by good management practices— a different season of use, a shorter grazing period near the stream, fencing off the stream, or developing water away from the stream.

Information about restoration

BLM continues to try to acquire additional lands in the Marys River ecosystem. Ecosystem health is improving, and all of the streams on BLM lands have been closed to cattle grazing (more than 8,400 hectares). BLM monitors the health of habitat, vegetation, streams, and archaeological and historic sites to assure that their condition is improving. Fences, riparian planting, conservation easements across private land, spring exclosures to keep cattle out, pipelines to move cattle watering to less sensitive areas, and fires to burn off less desirable vegetation so that plants useful to wildlife can grow are all projects BLM has accomplished with various partners in the past four years.

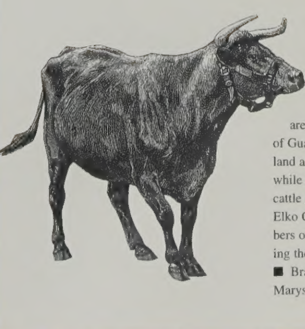
To address ranchers' concerns about the loss of available grazing lands and the county government's concerns about the loss of property tax revenue, the BLM worked with Olympic Management, Inc., to make additional lands available to ranchers in Elko County. This time the BLM exchanged 18,800 hectares of difficult-to-manage federal lands in Elko County, but not along streams, for other lands in southern Nevada owned by Olympic Management, Inc., which provide important habitat for the threatened desert tortoise. Olympic then sold the lands in Elko County to ranchers. The property tax base was restored to Elko County because BLM lands became privately owned and subject to property tax. The increase in hunting and fishing, because of improved access to public lands, resulted in recreationists spending an additional $600,000 a year on taxable recreation-related activities.

BEAVERS

The Marys River ecosystem in Elko County, Nevada, is a 290-km-long ribbon of life in the desert. Its broad wildlife-rich meadowlands were enhanced through centuries of beaver activity. Because beaver dams slowed the river's flow, wide curves and deep pools could be maintained. Slower water drops its sediment load, and over the centuries, valleys filled in and meadows were created that contained a wide diversity of plants and animals. The waters were rich with Lahontan cutthroat trout, and a great number of mammals, birds, and reptiles lived here, including river otters, antelopes, bobcats, and cranes. The mobile Western Shoshon tribe lived here, moving where plants and animals were seasonally available. In the 1820s Anglo-American beaver trappers arrived, killing the animals for their skins, which were then exported to the eastern United States and Europe to be made into hats. As a result, the animals were nearly exterminated from the area.

- Brainstorm all the ways the Marys River ecosystem would have changed with the disappearance of beavers.

CATTLE



Ranching became a way of life along the Marys River, beginning in the 1870s. Prior to the passage of the Taylor Grazing Act in 1934, cattle, sheep, and domestic horse grazing was uncontrolled and in some cases extremely heavy throughout the area. Most of the area was federally acquired in the Treaty of Guadaloupe-Hidalgo of 1848. Some of the land (particularly land attached to water) became privately owned homesteads, while the rest remained in public ownership but was used for cattle grazing. Today, ranching is still a major occupation in Elko County. Cattle stay near water and shade, and large numbers of them will congregate in and around riparian areas during the hot summer months.

- Brainstorm all the ways that cattle grazing could change the Marys River ecosystem.

RESTORATION

At one time the Bureau of Land Management (BLM) managed 35 percent of the Marys River ecosystem. In 1975, the Lahontan cutthroat trout was listed as a threatened species under the Endangered Species Act. Once a species is listed, BLM is required to coordinate management with the U.S. Fish and Wildlife Service to ensure that actions taken will not jeopardize that species's survival. The BLM wanted to improve the condition of the Marys River ecosystem, in part to help improve the habitat of the endangered fish and also to address problems in surrounding streams that had been caused by overgrazing of cattle. BLM was concerned, however, that any measures implemented in their lands would not be effective because 65 percent of the waterways still would be used by ranchers for cattle grazing.

The solution to the dilemma came from Las Vegas, Nevada, where BLM owned additional lands. BLM had found it difficult to manage their lands in this urban setting and had earmarked them for disposal in their land-use plans. Olympic Management, Inc., a development company, wanted the high-value Las Vegas land for housing and shopping malls. Olympic offered to buy private land from ranchers along the Marys River and then trade the land to BLM in exchange for the Las Vegas lands.

In 1991, BLM traded 264 hectares in Las Vegas to Olympic for about 18,800 hectares of Marys River, thus transferring 104 additional km of the ecosystem's streams to federal ownership (BLM originally managed 100 km along the Marys River). The BLM now managed 65 percent of the Marys River ecosystem streams, and both parties could more easily manage their own land.

- Brainstorm all the actions BLM biologists might take to restore health to the Marys River ecosystem.

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Kelly Rigby

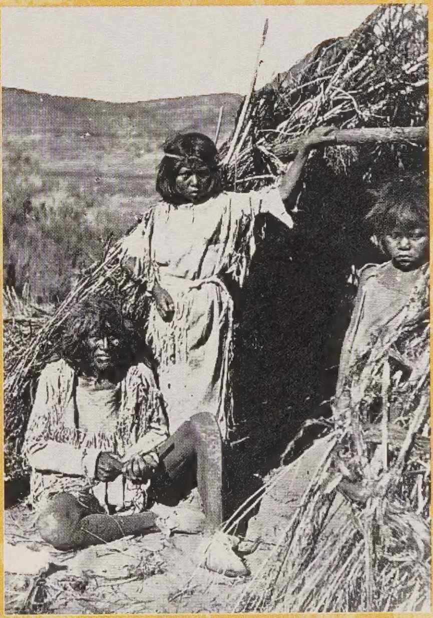
along the Marys River, and met some of the recreational needs in Elko County. An activity on the accompanying foldout provides a detailed account of how the citizens of Elko County worked with the BLM to improve the health of the land in a manner that resulted in economic and other benefits.

A Great Basin Full of Activities

- To help students understand the effect of salt on plants, obtain three identically sized plant cuttings rooted in water. Place one plant in a 10 g/L salt solution, another in a 50 g/L salt solution, and a third in plain water. Have students record the effects on the plants' roots and leaves.
- Residents of Las Vegas use twice as much water per capita as those of Tucson, Arizona, also located in a desert environment. Have students investigate why this is so and the kinds of measures Las Vegas could take to conserve water. (They could landscape with native desert vegetation, which requires less water; install showerheads and toilet tanks that use less water; establish restrictions on what times of the day and year people can wash their automobiles; and have restaurants offer water only upon request.)
- Have students design a plant or animal that is adapted to living in an arid environment. Include at least four characteristics that help this species survive.
- Have students research the other three deserts that occur in North America (Sonora, Mojave, Chihuahua) and identify their different characteristics. Compare and contrast with the Great Basin desert.
- Obtain two small cacti and two leafy plants (but please don't dig up native or wild ones). Over the course of two months, have students water only one of the cacti and one of the leafy plants, and record their observations of all four plants. After two months, the children can dissect both the cacti and observe the level of water accumulated in the fleshy parts of the plants. (Students must wear heavy, protective gloves for this activity.)
- To point out the Great Basin's impact on the national economy, have students research some of the resources derived from the area, including gold, potash, magnesium, pumice, salt, silver, water, beef, mutton, brine shrimp, pine seeds (sold as "pine nuts"), recreation, and scientific data

James Kirk Gardner

At the turn of the century, disease, fragmentation of habitat, and other factors led to a serious decline in bighorn sheep populations. Great Basin land managers have worked together to reverse this trend by capturing animals in areas with thriving populations and reintroducing them into the Basin.



Utah State Historical Society

Paiute Indians, *circa* 1873, in front of a *wickiup*, a temporary brush structure. Typically, early Great Basin peoples moved to where resources were seasonally available.

Looking to the Future

The "Big Empty" is no longer a vacant expanse with room for every use. Growing human populations; demands for water, minerals, and range forage; tourism; the maintenance of rural economies; and diverse plant and animal communities all strive for their place in the Great Basin. Compounding the problem are the serious ecosystem problems we already have. Land managers and local communities will have to make tough choices to achieve healthy ecosystems. Active public participation and partnerships among communities, land managing agencies, and private landowners will be essential to find solutions that everyone can live with. Finding these solutions is not only a local matter, because decisions about public lands have significance to our nation as a whole.

As tomorrow's decision-makers, today's students will play a key role in determining how our public lands are used, in developing new environmental technologies, and in finding creative solutions to tough problems. Their contributions will affect environmental conditions not only in this country but also in other countries around the world, who look to America for help in combating environmental challenges. To fulfill this responsibility, students will need to be informed about all sides of an issue and to understand why healthy ecosystems benefit everyone.

Kelly Rigby

about past environments and human cultures. As an extension, have students research the resources found in other deserts of the world (for example, oil from the Syrian Desert in Saudi Arabia).

- To explore the effects of temperature on water evaporation, you will need three same-size jars, salt, water, a graduated cylinder, and a 200-watt lamp on a stand. Label the three jars A, B, and C. Prepare a salt solution by dissolving 20g of salt in 60 mL of warm water, equally dividing the solution among the three jars. Mark the water level on each jar. Set jar A under the lighted lamp, jar B in an undisturbed place in the room, and jar C in a cool place. Make sure none of the jars is in a drafty place. For the next three days, have students record the water level at the end of each day. Students will note that evaporation occurs fastest in warm air temperatures, and slowest in cool temperatures.
- Research major climatic changes in the Great Basin over the last 5,000 years. Use the information to write a history of a bristlecone pine, and to prepare a graphic depicting the climatic changes as read through the tree's rings.
- The prehistoric cultures of the Great Basin adapted to its unpredictable and fluctuating resources. Research the Fremont and Desert Archaic cultures, and the modern Paiute, Goshute, and Shoshone peoples, noting the adaptations they made.
- Forecast the consequences of climatic changes in the Great Basin, including global warming and cooling. What would the effects be on animals? On plants? On human activities and settlements?
- On a map showing contour lines, have students prepare acetate overlays of the area modern lakes would cover if they were to rise various amounts. Refer to a Utah map for the Great Salt Lake/Lake Bonneville and to a Nevada map for the Carson Sink/Lake Lahontan, and research prehistoric lake levels.
- As a class activity, have students brainstorm ways to maintain the health of Great Basin ecosystems while still allowing the public to use the land in varied ways.

Did You Know...?

- Nevada, the nation's most arid state, sustains the largest number of threatened and endangered fish species.
- Ancient remains in the Great Basin range from microorganisms associated with the earliest life-forms some 2.8 billion years old to evidence of human migrations to the Western Hemisphere 12,000 to 15,000 years ago.
- The Great Basin sustains the nation's largest colony of white pelicans at Anaho Island, situated in Pyramid Lake.
- Brine shrimp (the crustaceans sold as fish food for home aquarists) grow in great abundance in the Great Salt Lake, thriving in the green algae that live in its saline waters.
- Over 40,000 wild horses and burros roam the western ranges, many in the Great Basin states.
- Almost one million hectares of public lands in the Basin are being considered for special status as wilderness areas.
- In 1994, 5.6 million people visited the public lands in Nevada for recreation. Hiking, scenic driving, camping, bicycling, photography, picknicking, and four-wheel drive excursions were the most popular activities.
- The water of ancient Lake Bonneville has dropped from 300 m deep to an average of 3.9 m in today's Great Salt Lake. More than seven billion metric tons of salt are left behind as a reminder of earlier geologic activity.

Resources

The United States Geological Survey (USGS) has free-of-charge teacher packets available for distribution. The packets, tailored to grade level, include information on maps, mapping sciences, and history. Topographic maps and the free packets can be ordered from the USGS Earth Science Information Center, 507 National Center, Reston, VA 22092; tel. 800-872-6277.

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